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General Mathematics Placement Test (MPT-G): 2009 Pilot Study

Debbie McGhee, Nana Lowell, Jerry Gillmore, and Jon Peterson
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INTRODUCTION

The Intermediate Mathematics Placement Test (MPT-I) has been used for many years to place students into entry-level math courses at Washington state public baccalaureate institutions. The MPT-I was developed to assess student readiness for the traditional precalculus-calculus sequence; however, the focus in post-secondary math education has recently expanded to include a broader range of entry-level math courses as reflected in the recent Washington state College Readiness Mathematics Standards (CRMS). In 2007, Washington state legislators mandated that the Mathematics Placement Test (MPT) be revised to serve as a common college readiness test for all two and four-year institutions of higher education in Washington state, and that all institutions use a common performance standard on the test for purposes of determining college readiness in mathematics.[1]

For the past two years, math faculty from four-year, two-year, and K-12 schools have worked together to create the new General Mathematics Placement Test (MPT-G).[2] The MPT-G has been developed to place students into a wide array of entry-level math courses, and to provide the basis for computing a single consistent index of students' readiness for college-level mathematics.[3] This report describes the results of a pilot study conducted to inform discussions among faculty as they set a specific cut score on the MPT-G to serve as the criterion for college readiness. Two research questions of particular interest were: 1) How does student performance on the new MPT-G compare with their performance on the MPT-I? 2) How well do student test scores predict subsequent course grades?

METHOD

The pilot study was conducted between October 2008 and June 2009. The MPT-G and MPT-I were administered to groups of high school and post-secondary students, and subsequent course grades were provided by participating institutions. Student participation was solicited through representatives of four-year, two-year, and K-12 schools and tests were administered in one of two modes (testing center vs. testing site).

Testing Centers

Institutions that participate in the Academic Placement Testing Program (APTP) administer Math Placement Tests on a regular basis as part of ongoing enrollment and registration. Tests are administered in campus testing centers and the results are used to place students into mathematics courses. For purposes of the pilot, four four-year institutions agreed to administer

[1] Second Substitute House Bill 1906, section 10.
[2] This collaboration is described at http://www.washington.edu/oea/services/testing_center/crmt/about_crmt.html.
[3] Development of the MPT-G is described at http://www.washington.edu/oea/pdfs/reports/OEAReport0801.pdf.

the MPT-G and MPT-I alternately to students who would otherwise take the MPT-I during autumn through spring academic terms. Tests were administered under controlled conditions as specified in the *APTP Testing Center Manual*. As shown in Table 1, tests were completed by 1215 students in this mode. Test results were used to determine actual course placements for students.

Table 1. Number of completed tests and grades by institution and test type.

		Completed Tests			Completed Tests and Grades		
Type of Institution	Mode*	MPT-G	MPT-I	Total	MPT-G	MPT-I	Total
Total		1681	2014	3695	1024	1337	2361
Four-Year Institutions							
Eastern Washington University	TC	344	302	646	93	90	183
University of Washington	TC	76	158	234	29	80	109
Washington State University	TC	54	125	179	17	54	71
Western Washington University	TC	67	89	156	35	60	95
Subtotal		541	674	1215	174	284	458
Evergreen State College	TS	16	18	34	0	0	0
Subtotal		557	692	1249	174	284	458
Two-Year Institutions							
Edmonds Community College	TS	46	43	89	41	39	80
Spokane Falls Community College	TS	67	70	137	0	0	0
Subtotal		113	113	226	41	39	80
High Schools							
Anacortes High School	TS	83	87	170	82	86	168
Bellingham High School	TS	59	69	128	59	68	128
Blaine High School	TS	70	71	141			0
Eastside Catholic High School	TS	15	14	29	15	14	29
Evergreen High School	TS	11	19	30	6	11	22
Ferndale High School	TS	77	69	146	77	68	145
Heritage High School	TS	28	28	56	26	27	53
Lynden Christian High School	TS	34	41	75	34	41	75
Mountain View High School	TS	87	148	235	65	114	180
Mt. Baker High School	TS	7	8	15	7	8	15
Naches Valley High School	TS	8	6	14	8	6	14
Nooksack Valley High School	TS	35	52	87	34	50	87
North Central High School	TS	69	94	163	39	92	131
Prairie High School	TS	50	45	95			0
Prosser High School	TS	19	17	36	19	17	36
Shadle Park High School	TS	128	122	250	121	116	237
Shoreline School District	TS	2	1	3	2	1	3
Sumner School District	TS	50	71	121	45	71	118
Union High School	TS	64	136	200	51	111	162
Wapato High School	TS	13	13	26	13	13	26
West Valley High School	TS	102	98	200	101	96	197
Subtotal		1011	1209	2220	804	1010	1814

* TC=Testing Center; TS=Testing Site

Testing Sites

To provide test data for students from other educational sectors, representatives from Evergreen State College, community and technical colleges, and high schools administered the MPT-G and MPT-I to groups of students during winter and spring 2009. Students were given either the MPT-G or MPT-I (assigned alternately) and were able to use their test results for placement at four-year institutions. Some administrations were conducted in auditoria, some in

testing centers, and others in the classroom. Tests were administered under controlled conditions as specified in an administration manual modeled on the *APTP Testing Site Manual*. As shown in the Table, 34 four-year students, 229 two-year students, and 2220 high school students participated in this mode.

Table 1 also shows the number of students for whom both test and grade data were available. Four-year institutions (with the exception of the Evergreen State College) submitted student grades in the first math course in which they enrolled subsequent to testing. All other institutions submitted grades for courses in which students were currently enrolled. We particularly requested participation of students who were just completing Algebra II/Trigonometry or Integrated Math 3, or who were entering Precalculus or other college level mathematics courses, as these courses would be most useful in helping to define college readiness. However, other student groups were included as requested by specific institutions.

For the purpose of analysis, all letter grades were converted to numeric values according to the scheme given in Table 2. Grades that did not count toward a student's GPA (e.g., Withdrew or Satisfactory) were treated as missing. As shown in the table, numeric grades were available for 64% of all test-takers.

Table 2. Letter-to-number grade conversion table.

Letter grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Numeric equivalent	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	.7	0

RESULTS

Test Reliability

Both the MPT-G and MPT-I showed high internal consistency (α = .84 and .85, respectively).

Test Difficulty

Students found the MPT-G to be more difficult than the MPT-I (*Mn* = 18.4 and 20.4, respectively, as shown in Table 3). This difference was statistically significant, $F(1, 3689) = 33.6$, $p < 10^{-8}$. Both tests were fairly difficult; given the total possible score of 35 on each test, the percentage equivalents for the respective means were 52.6% and 58.3%.

Table 3. Average total score by administration mode and type of institution.

	MPT-G			MPT-I		
Mode / Institution	Mean	SD	n	Mean	SD	n
Overall	18.4	6.5	1681	20.4	6.4	2014
Four-Year Institutions	18.2	6.2	557	21.0	6.1	692
Two-Year Institutions	18.8	6.2	113	20.1	6.4	113
High Schools	18.5	6.7	1011	20.1	6.5	1209

Although we attempted to match the overall difficulty of the new MPT-G and revised, three-option MPT-I[4] to the original five-option MPT-I, we were successful only with respect to the MPT-G. The average MPT-G total score was the same as that observed for the original MPT-I during the 2007-2008 APTP testing year (*Mn* = 18.4).

Table 3 also shows the average test scores by type of institution. In addition to the statistically significant main effect for test type, we found a significant interaction between test type and type of institution, $F(1,3689) = 3.5$, $p = .03$. The difference in student performance on the MPT-G and MPT-I was less pronounced among students from high schools and two-year institutions than among four-year students. In particular, there was no significant difference in performance on the two tests among students from two-year schools (Figure 1); however, it is difficult to know how generalizable this result is given the extremely small number of students from this sector. It is possible that differences across institution type were somehow related to differences in student incentive: students at four-year institutions took the tests as part of the normal course registration process, whereas students at high schools and two-year institutions did not have this same motivation.

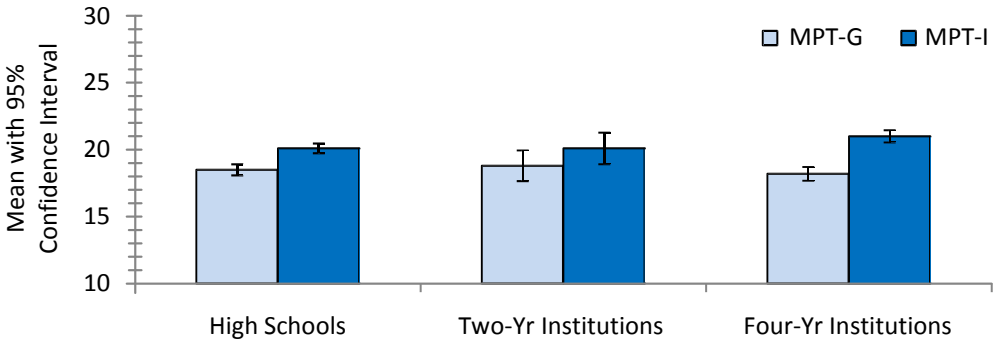

Figure 1. Average total score by test type and institution type.

Test Scores and Grades

Tables 4-6 show the average MPT total score by course type and level, and correlations between MPT total score and course grade within each of the three sectors. For the purpose of these analyses, high school statistics, precalculus, and calculus courses were identified as "college level" courses. Although total test scores of high school, two-year, and four-year students were not significantly different from one another ($F(2,3689) = .7$), total test scores of students in college level courses were significantly higher than those not in college level courses. A six point difference was observed for both the MPT-G (*Mns* 22.1 and 16.1), $F(1,2443) = 274$, $p < 10^{-57}$, and the MPT-I (*Mns* 23.7 and 17.7), $F(1,2443) = 360$, $p < 10^{-74}$ (see Figure 2). Importantly, these main effects were *not* qualified by an interaction with type of institution; that is, the magnitude of the effect of course level on test score was similar in high schools and four-year schools.

[4] To match the format of the new General Math Placement Test, the existing Intermediate and Advanced tests were converted from five-option multiple-choice items to three-option items based on the results of a pretest conducted during the spring 2008 APTP statewide testing.

Table 4. Correlations between total score and course grade among high school students.

	MPT-G				MPT-I			
Type and Level of Course	Mean	SD	*r*	n	Mean	SD	*r*	n
Overall	18.6	6.8	.41†	804	20.2	6.5	.42†	1010
Below Algebra II	13.4	4.8	-.23	10	13.3	3.5	.40	19
Integrated 2	13.3	4.9	.31*	45	17.3	5.6	.41†	70
Integrated 3	15.2	5.2	.37†	183	17.8	5.3	.24†	264
Algebra II+	18.5	6.1	.49†	234	18.9	5.5	.38†	237
College Transition	14.5	4.9	.19	24	14.8	4.7	.61*	17
Statistics	21.7	6.2	--	7	23.8	5.8	.52*	36
Precalculus	27.0	4.9	.40†	223	28.1	5.8	.50†	276
Calculus	18.3	9.7	.52†	51	19.0	6.3	.55†	65
Other	14.8	5.8	.11	27	17.7	4.9	-.12	26
Below college level	16.4	5.9	.41†	523	17.9	5.4	.31†	633
College level	22.6	6.4	.44†	281	24.1	6.3	.52†	377

Note. * $p < .05$, † $p < .001$

Table 5. Correlations between total score and course grade among students at two-year institutions.

	MPT-G				MPT-I			
Type and Level of Course	Mean	SD	*r*	n	Mean	SD	*r*	n
Overall	20.2	5.9	.26	41	20.8	6.5	.33*	39
Below Algebra II								
Integrated 2								
Integrated 3								
Algebra II+								
College Transition								
Statistics								
Precalculus	20.3	6.0	.27	40	20.9	6.5	.35*	38
Calculus								
Other			--	1			--	1
Below college level				1				1
College level	20.3	6.0	.27	40	20.9	6.5	.35	38

Note. * $p < .05$, † $p < .001$

Table 6. Correlations between total score and course grade among students at four-year institutions.

	MPT-G				MPT-I			
Type and Level of Course	Mean	SD	*r*	n	Mean	SD	*r*	n
Overall	18.9	6.3	.42†	174	21.6	6.3	.39†	284
Below Algebra II	9.8	3.8	.37	19	10.0	4.9	-.01	11
College Transition								
Integrated 2								
Integrated 3								
Algebra II+	13.5	2.6	.03	27	14.6	3.9	.27	38
Statistics			--	4			--	8
Precalculus	24.0	3.8	.32	33	25.1	4.6	.12	71
Calculus	--	--	--	3	--	--	--	2
Other	20.5	5.1	.31*	88	22.4	5.1	.42†	154
Below college level	12.4	3.8	.20	50	14.6	5.1	.33*	60
College level	21.6	5.0	.31*	124	23.5	5.1	.30†	224

Note. * $p < .05$, † $p < .001$

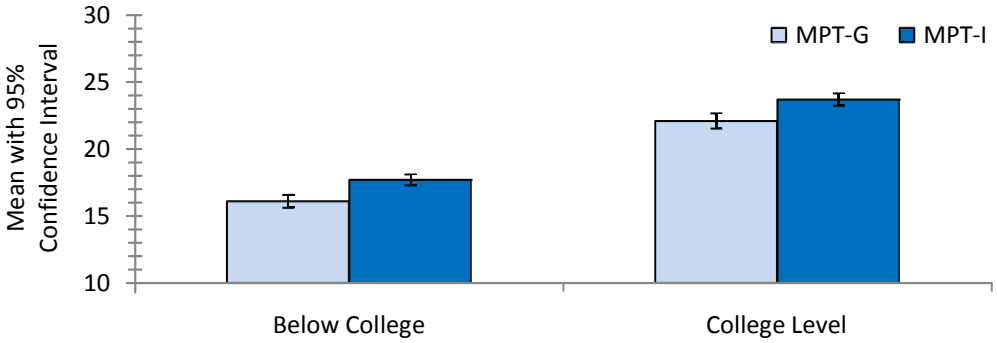

Figure 2. Average total score by test type and course level.

Figure 3 shows mean MPT-G and MPT-I scores by type of course, for all institution types. Students enrolled in higher level math courses tended to receive higher test scores, providing confirmatory evidence of the validity of the tests. For example, the traditional Algebra II-Precalculus-Calculus sequence shows steadily increasing mean scores, with a consistent one-point difference between performance on the MPT-G and MPT-I. Larger differences (three- to four-points) were observed for Integrated 2 and 3 courses, and for the heterogeneous Other category.

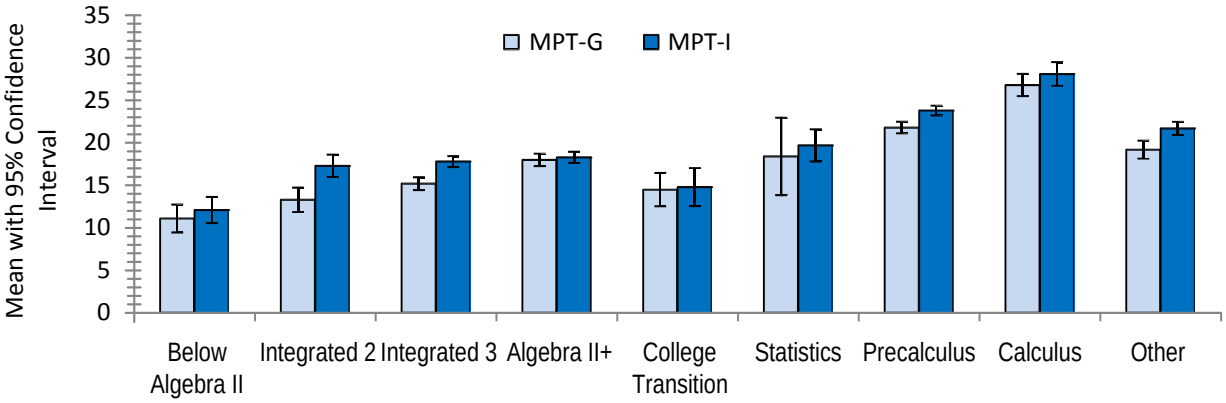

Figure 3. Average total score by test type and course.

As shown in Tables 4 and 6, MPT scores were moderately (and statistically significantly) correlated with math course grades within both high schools and four-year schools. In each instance, total test score correlated about r = .4 with course grade. Within high schools correlations were also significant at the level of specific types of courses (e.g., Integrated 3, Calculus, etc.). At four-year schools the course-type-level correlations were attenuated because MPT scores had been used for placement into those math courses. Nevertheless, both MPT-G and MPT-I total scores did predict college level and non-college level grades as a group.

Although zero order correlation coefficients provided clear evidence of the relationship between test scores and course grades within the high schools, performance in college level courses is more directly related to discussions of college readiness. For this reason, we carried out additional analyses focusing specifically on data provided by the four-year schools in which students were placed into courses by their test scores (i.e., EWU, UW, WSU, and WWU).

As shown in Table 7, the majority of students at four-year schools completed those courses with a numeric grade of 2.0 or better. Specifically, 70.6% of those in the MPT-G group were subsequently "successful," as were 69.0% of the MPT-I group. Additionally, students who achieved a course grade of at least 2.0 tended to have scored significantly higher on the MPT than those who did not, $F(1,450) = 13.8$, $p = .0002$. This difference was observed on both the MPT-G (*Mns* = 15.8 *vs.* 20.4) and MPT-I (*Mns* = 18.4 *vs.* 23.1).

Table 7. Average total score by course grade and level of course (four-year schools).

	MPT-G			MPT-I		
Level of Course and Course Grade	Mean	SD	n	Mean	SD	n
Overall						
Below 2.0	15.8	5.9	54	18.4	5.9	88
2.0 or Greater	20.4	6.0	120	23.1	5.9	196
Below college level						
Below 2.0	11.7	3.9	27	13.8	4.2	33
2.0 or Greater	13.2	3.6	23	15.6	6.0	27
College level, General						
Below 2.0	18.1	2.7	18	19.4	4.7	36
2.0 or Greater	21.3	5.4	70	23.7	4.8	115
College level, Precalculus+						
Below 2.0	23.7	5.1	9	24.5	3.5	19
2.0 or Greater	24.1	3.4	27	25.5	5.0	54

Logistic regression analyses indicated that the two tests were equally successful at predicting course success within four-year schools. As shown in Table 8, both the MPT-G and MPT-I total test scores were significant predictors of course success. Furthermore, a Wald chi-square test for a difference between the logit coefficients by test type was not significantly different from zero, $\chi^2(1) = .03$, $p = .86$. In other words, MPT-G and MPT-I total test scores were equally effective in predicting course success. This analysis was repeated for college-level courses only and for EWU[5] separately from the other three schools: in neither instance did the logit coefficients differ by test type.

Table 8. Logistic regression coefficients by test type (four-year schools).

Test Type and Predictor	Logit (B)	SE(B)	Odds Ratio (Exp(B))
General			
Constant	-1.58	.57	.20
Total Test Score	.13	.03	1.14
Intermediate			
Constant	-1.81	.48	.16
Total Test Score	.12	.02	1.13

[5] Examiners at EWU recognized the difference in student performance on the MPT-G and MPT-I early in the testing year, and adjusted their placement cut scores accordingly.

To provide more specific information for setting a college readiness cut score, the observed rates of course success (i.e., grade equal to or greater than 2.0) in non-precalculus/calculus college-level courses are shown in Figure 4 as a function of MPT total score. The MPT-I line conforms to the shape of an ideal trend line (i.e., monotonically increasing), but the line for the MPT-G does not. However, the errors bars in the graph indicate that the observed proportions for the two tests at each score point were not significantly different.

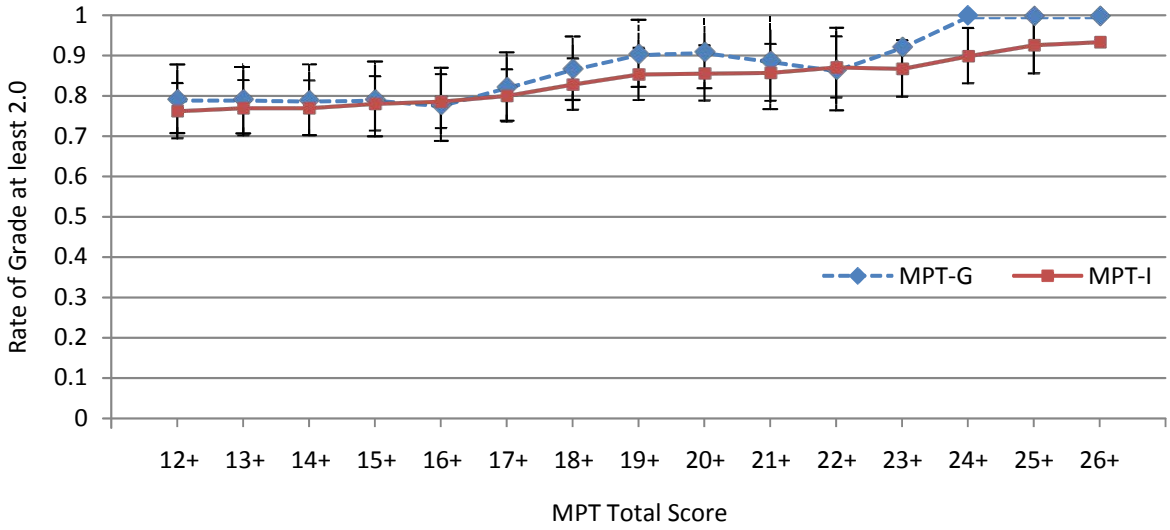

Figure 4. Observed rates of success in non-precalculus/calculus college level courses as a function of total test score (4-year schools).

Table 9 shows the observed rates of success for test scores similar to those currently in use at four-year schools as placement cut scores. The cut score for the MPT-I is shown as two points higher than that for the MPT-G to reflect the difference in test difficulty.

Table 9. Observed rates of success for selected MPT-G and MPT-I cut scores.

MPT-G cut score	15+	16+	17+	18+	19+	20+	21+
	.79	.78	.82	.87	.91	.91	.89
MPT-I cut score	17+	18+	19+	20+	21+	22+	23+
	.80	.83	.85	.86	.86	.87	.87

SUMMARY POINTS

- Total test scores were statistically reliable for both MPT-G and MPT-I.
- The MPT-G and MPT-I were both fairly difficult (52.6% and 58.3% total correct, respectively).
- The MPT-G was more difficult than MPT-I by approximately two points. This difference was largely due to the performance of students enrolled in integrated math courses who showed a much greater difference in performance on the two tests than did students taking other courses.
- Discriminant validity was demonstrated for both tests by the superior performance of students taking college level math courses over those in pre-college level courses.
- Predictive validity was demonstrated for both tests by the significant correlations between total test scores and mathematics course grades. Though modest, significant effects were obtained even at four-year schools where the test scores had been used for placement.
- It was striking that, overall, students at four-year universities did not score significantly better than students at high schools. Moreover, whereas high school students in college-level courses obtained mean scores that were indistinguishable from those of college-level university students, high school students in pre-college courses actually outperformed the complementary university group. One interpretation is that the highest performing math students tend to retain their math skills from high school until the time they sit for the MPT.

APPENDIX. COURSE NAMES, CATEGORIES, AND LEVELS

Sector	Course Name	Category	College Level
1	Algebra II w Trig	Algebra II+	no
1	Algebra II	Algebra II+	no
1	Algebraic Functions w/ Trig	Algebra II+	no
1	College Algebra w/ Trig	Algebra II+	no
1	PRE-AP ALG TRIG	Algebra II+	no
1	ALGEBRA 2B	Algebra II+	no
1	Advanced Algebra	Algebra II+	no
1	Algebra II	Algebra II+	no
1	Algebra II	Algebra II+	no
1	AdvAlg/ Integrated 3B	Algebra II+	no
1	Algebra II	Algebra II+	no
2	Intermediate Algebra	Algebra II+	no
3	Intermediate Algebra	Algebra II+	no
3	Intermediate Algebra	Algebra II+	no
3	Intermediate Algebra	Algebra II+	no
1	Algebra I	Below Algebra II	no
1	Geometry	Below Algebra II	no
3	Basic Algebra for College Students	Below Algebra II	no
3	Beginning Algebra (SFCC)	Below Algebra II	no
3	Introductory Algebra	Below Algebra II	no
1	AP AB CALC 2	Calculus	yes
1	AP CALCULUS 2	Calculus	yes
1	AP CALC AB 2	Calculus	yes
1	Calculus AB/AP2	Calculus	yes
1	Calculus AB/AP2	Calculus	yes
1	AP CALC AB 2	Calculus	yes
3	Mathematical Analysis for Architects	Calculus	yes
3	Introduction to Math Analysis	Calculus	yes
3	Calculus and Analytic Geometry	Calculus	yes
3	Calculus with Applications to Business and Economics	Calculus	yes
1	College Readiness Bridge Course	College Prep	no
1	Transition to College Math 601	College Prep	no
1	INT ALG/GEO 1B	Integrated 1	no
1	INT ALG/GEOM 1B	Integrated 1	no
1	INT ALG/GEO 2B	Integrated 2	no
1	ALG/GEO/PRECAL2	Integrated 2	no
1	INT ALG/GEO 2B	Integrated 2	no
1	Accelerated Integrated 2	Integrated 2	no
1	Integrated II	Integrated 2	no
1	INT AL/GEO 2A/2B	Integrated 2	no
1	INT ALG/GEOM 2B	Integrated 2	no

APPENDIX. COURSE NAMES, CATEGORIES, AND LEVELS (CONTINUED)

Sector	Course Name	Category	College Level
1	INT ALG/GEO 3B	Integrated 3	no
1	INT ALG/GEO 3B	Integrated 3	no
1	Integrated 3	Integrated 3	no
1	Integrated 3B	Integrated 3	no
1	Integrated III	Integrated 3	no
1	Integrated III/60	Integrated 3	no
1	Integrated III-A	Integrated 3	no
1	Integrated III-B	Integrated 3	no
1	HONORS ALG 2B	Integrated 3	no
1	HONORS ALG/TRIG	Integrated 3	no
1	INT ALG/GEO 3B	Integrated 3	no
1	INT ALG/GEOM 3B	Integrated 3	no
1	Integrated 4	Integrated 4	yes
1	Understanding Math	Other	no
1	Finance	Other	no
1	APPLIED MATH 1B	Other	no
1	Math in the Modern World	Other	no
1	Quant Math/2nd	Other	no
2	Math in Society	Other	yes
3	Finite Mathematics	Other	yes
3	Mathematical Reasoning	Other	yes
3	Algebra with Applications	Other	yes
3	Introduction to Elementary Functions	Other	yes
3	Exploring Mathematics	Other	no
3	Introduction to Mathematics Analysis for Business and Economics	Other	yes
3	Math For Elementary School Teachers I	Other	yes
3	Algebra with Applications to Business and Economics	Other	yes
3	Functions and Algebraic Methods	Other	yes
3	Mathematical Reasoning and Its Applications	Other	yes
3	Quantitative Reasoning	Other	yes
3	Teaching K-8 Mathematics	Other	yes
3	Algebra Concepts	Other	yes
1	Precalculus	Precalculus	yes
1	Precalculus w Trig	Precalculus	yes
1	Pre Calculus	Precalculus	yes
1	PRE CALCULUS B	Precalculus	yes
1	PRE-CALCULUS 2	Precalculus	yes
1	Precalculus	Precalculus	yes
1	Precalculus I	Precalculus	yes
1	PRE-CALCULUS 2	Precalculus	yes
1	MAT 450 Precalculus Honors	Precalculus	yes
1	Pre-Calculus 2	Precalculus	yes
1	Precalculus 2	Precalculus	yes
1	PRE CALC 2	Precalculus	yes
1	College in HS Precalulus 402	Precalculus	yes

APPENDIX. COURSE NAMES, CATEGORIES, AND LEVELS (CONTINUED)

Sector	Course Name	Category	College Level
2	Business Precalculus	Precalculus	yes
2	Precalculus	Precalculus	yes
3	Precalculus I	Precalculus	yes
3	Precalculus	Precalculus	yes
3	Precalculus	Precalculus	yes
3	Accelerated Precalculus	Precalculus	yes
3	Precalculus	Precalculus	yes
1	AP Stats	Statistics	yes
1	Stats	Statistics	yes
1	AP STATISTICS 2	Statistics	yes
1	Stats 2/AP	Statistics	yes
3	Introduction to Statistical Methods	Statistics	yes
3	Statistical Thinking	Statistics	yes
3	Introduction to Statistics	Statistics	yes
1	Collection Of Evidence MATH S2	WASL Remedial	no
1	Collection Of Evidence MATH S2	WASL Remedial	no
1	SEGMENTED MATH	WASL Remedial	no